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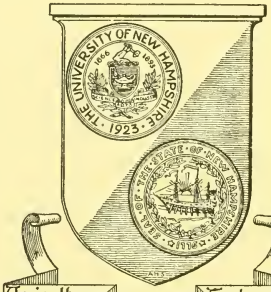
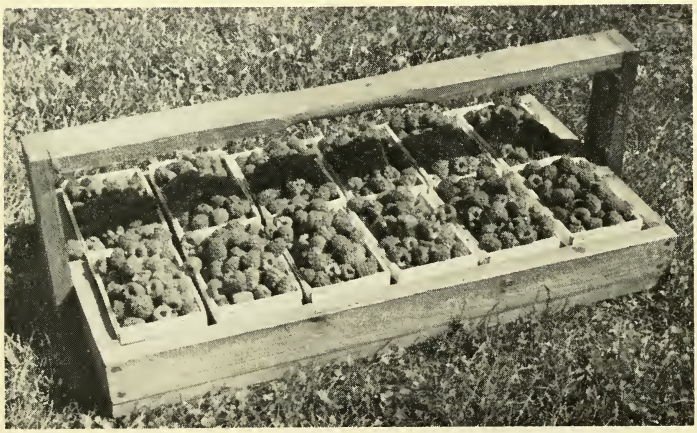


The University
of
New Hampshire

BREEDING BETTER FRUITS AND NUTS

By

A. F. YEAGER and E. M. MEADER



New Hampshire raspberry, a large, high-quality summer bearing variety that grows well in the north.

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Breeding Better Fruits and Nuts

By A. F. Yeager and E. M. Meader*

THIS bulletin covers the breeding work with fruits and nuts of the Horticultural Department from 1950, when Station Bulletin 383 was issued, until 1957. The cooperation of many persons has made possible the development of the new improved varieties. Breeding of strawberries was done by L. P. Latimer previous to 1950. The varieties, Blaze, Strafford, and Jamberee that resulted and which have been named since 1950, are included for completeness. A. F. Yeager has assumed leadership in the raspberry breeding, while E. M. Meader has taken the lead in blueberry breeding. Selected plants of the improved kinds are tested both by other experiment stations and growers skilled in handling a certain crop before being introduced as a new variety. When a new variety is officially named and released, propagation material is supplied to cooperating nurserymen and plant growers for increase. They make the variety available to the general public since the New Hampshire Agricultural Experiment Station does not maintain a commercial nursery.

Apple Breeding

Apple breeding was begun at the New Hampshire Agricultural Experiment Station in 1942. First, Northern Spy was pollinated with Macoun and second, Winter Banana was pollinated with McIntosh. The second cross was considered the most promising for the origination of a variety having the tree shape and size of Winter Banana, annual uniform fruit crops, long-keeping fruits, and the high edible quality of McIntosh. Five hundred seedlings were set in the field in the spring of 1943. The first eliminations from this block of seedlings were made for susceptibility to cedar rust and about one-half of them were removed. Of the remainder, only the vigorous plants were left to fruit. The first selections were tagged in 1954. Since then NH #8, a seedling from Winter Banana x McIntosh, has been propagated to a limited extent for further testing. NH #8 has solid blush-type red fruits of Winter Banana size and shape. The firm hard apples ripen later than McIntosh and keep well all winter in cold storage. The fruits have some of the flavor of McIntosh but are firm in texture. The original seedling tree

New Hampshire No. 8 apple, from a cross between Winter Banana and McIntosh. This is a late-keeping, red, firm, regular cropping variety.

* Dr. Yeager is Horticulturist and Mr. Meader is Associate Horticulturist in the Agricultural Experiment Station.

has cropped regularly every year since 1954 including 1956 when some standard varieties lost a crop because of spring frosts.

In 1948, a thousand more seedlings of Winter Banana x McIntosh were planted. Some of these cropped in 1955 and 1956. The seedlings that had not been eliminated in the two preceeding years fruited in 1957. One tree that produces bright solid red fruits of medium size and which has a flavor resembling Jonathan has been saved for further observation. Five other seedlings having fruits of some promise have been held also for further testing. No seedling has yet proved sufficiently outstanding to warrant propagation.

In 1956, a seedling designated NH #C from the cross of Northern Spy and Macoun was selected for limited propagation. Fruits of this selection resemble Macoun in color and shape but they are much larger than the Macoun. NH #C has crisp good-keeping apples, but it has shown a tendency to alternate bearing. Also in 1948, about 120 more seedlings of Northern Spy x Macoun and reciprocal were planted. Some of these seedlings fruited in 1947. None have been tagged yet for propagation.

Triploid Apple Breeding

Such important commercial apples as Baldwin and Gravenstein and some others differ from common varieties in that they have three sets of chromosomes and are called triploids. The common varieties having two sets of chromosomes are called diploids. Crosses were made between a tetraploid McIntosh and Winter Banana in an attempt to produce a triploid variety of the McIntosh type.

A portion of a McIntosh tree growing in the orchard of Roger Kimball, Littleton, Massachusetts, produced giant fruits and proved to be tetraploid. Flowers on the tetraploid branches were pollinated with Winter Banana pollen on May 12, 1948, and set fruits abundantly. In the greenhouse during the spring of 1949, 97 percent of the seeds from the Kimball 4n McIntosh x Winter Banana cross germinated. Thus Dr. Charlotte G. Nast, Botany Department, University of New Hampshire, was able to obtain root tips for a cytological examination from 371 individual seedlings out of the progeny of 435 trees before they were transplanted to the open field in Greenland, New Hampshire. All of the seedlings examined were found to have a triploid count of chromosomes with three exceptions: definitely a diploid plant, a seedling having less than 51 chromosomes and thought to be diploid, and a pentaploid. This latter was a weak tree and died after two years.

The triploid progeny of Kimball 4n McIntosh x Winter Banana is rather variable, being similar to the diploid progeny of Winter Banana x McIntosh in this respect. Some trees are weak; others are vigorous and make good desirable trees. Only a few of these seedlings have fruited yet, though many of the trees have blossomed. Late spring frosts have been a problem for the past two years.

In addition, several hundred open-pollinated seedlings from the Kimball 4n McIntosh that are only of one year less age than the above cross are being grown. This progeny also shows many weak trees, though some make a strong growth. These trees should fruit next year.

Fruit seed stratified in individual pots with metal labels ready to be buried in the soil over winter for planting the next spring.

Breeding Tetraploid Apples

In the spring of 1950, Dr. L. F. Hough, New Jersey Agricultural Experiment Station, furnished seeds of Kimball 4n McIntosh x Wrixparent. The latter was the only other tetraploid apple readily available for pollen for crossing with the Kimball 4n McIntosh at Littleton, Massachusetts, in 1949. Wrixparent is a large green apple. A progeny of 75 seedlings of this cross is being grown at Durham, New Hampshire, and some should fruit in one or two more years. Their value may be mostly for use in further breeding work to produce good triploid varieties.

Breeding for Resistance to Apple Scab

In 1955, the New Hampshire Station entered actively a cooperative project with three other states — New Jersey, Indiana, and Illinois — to breed scab-resistant apples. For several years previous to 1955, trees at Durham, New Hampshire, were used for parents in making of crosses with those apple varieties or species showing a high degree of resistance to apple scab. The seeds were sent to Indiana and Illinois where the seedlings were started, tested for susceptibility to scab in the greenhouse, and then the resistant ones grown to fruiting in the open field. Not until 1955 were the first seedlings that had been screened for resistance to scab planted at Durham. More were planted in 1956 and 1957 and a total of 620 are now growing in the field. While the parentage of the several progenies varies and is not listed here in full, many of the crosses have McIntosh as one parent. Since New Hampshire excels in growing the McIntosh variety, it was considered proper to grow progenies of the scab-resistant apples involving McIntosh in their ancestry to fruiting in this state. Although no fungicide was applied to the seedlings in 1955 and 1956, the leaves of all seedlings showed freedom from apple scab. Powdery mildew has, however, become serious in these scab resistant progenies, so much so that it has been necessary to apply a sulphur dust to the foliage of the trees to prevent loss of leaves and a dieback of the twigs. Mildew restricted seriously the growth of some of the seedlings in 1956.

None of these seedlings have reached fruiting age yet. This is a long-time project, but a promising one. Once a good quality scab-resistant apple has been produced, the cost of commercial apple production can be greatly reduced, and the home owner might once again find it feasible to grow apples for home use.

Cherry Breeding

Sour cherries have been more reliable than the sweet cherries at Durham, New Hampshire. Both types fruit, except following the coldest winters. The duke cherries coming from crosses of the two species are intermediate between the sweets and sours. Belle Magnifique, a duke cherry, has fruits that at Durham have been given a top place in quality for general use. The variety has tended to produce rather light crops.

Since the trees of Belle Magnifique stand in the orchard among several varieties of both sweet and sour cherries, it was decided to grow open-pollinated seedlings from this duke cherry. It is hoped that a productive cherry with fruits equal to Belle Magnifique can be obtained. About 800 seedlings have thus been started and a few had some blossoms in 1957, though no crop has been harvested yet. This is an extremely variable progeny. Some trees have not survived the first winter in the open field. Others are weak and make little progress, but there are also some that are vigorous though of dwarf stature. Other vigorous tall trees, more nearly resembling the sweet cherry, look rather promising. Whether the open-pollinated seedlings have resulted from self pollination or backcrossing to one and/or both sweet and sour varieties nearby cannot be determined. A controlled pollination trial on Belle Magnifique gave some fruits with sweet cherry, none with sour cherry pollen. There are some promising seedling trees in the group and their fruiting response will be followed with much interest.

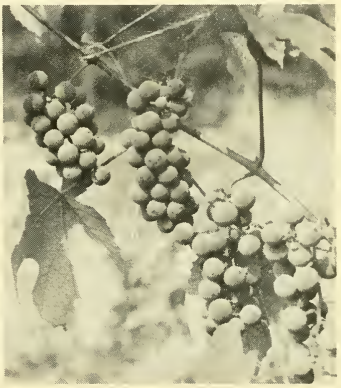
Wild Cherry Crosses

On November 14, 1952, pollen of the Capulin cherry, collected through the courtesy of the American Consul by Mr. Lee Haines at Ambato, Ecuador, South America, was received by air mail. The pollen was stored in a desiccator over calcium chloride. The desiccator was held in a refrigerator until late May or early June of the following year when wild black cherry trees flowered at Durham, New Hampshire. Emasculated flowers of the wild black cherry were pollinated with the stored Capulin cherry pollen. A small number of seeds were harvested and following stratification two seedlings grew. Two vigorous trees have resulted and although they blossomed for the first time in 1957, no fruits have set. Whether the trees are hybrids must be proved. If so, it may be possible to develop a cultivated cherry bearing fruits in long clusters.

Grapes

A prime requisite for grape production in New Hampshire is early maturity. Concord does not mature in the average season. Varieties such as Kendaia, Van Buren, and Fredonia ripen successfully most years only in

southern New Hampshire. In variety trials, Erie was found to be the earliest, good-quality, blue grape, but it is male sterile; hence, when grown, Erie must be planted with some other perfect-flowered variety. In 1950, of the many varieties in the vineyard at Durham, New Hampshire, only Erie, Van Buren, Kendaia, and Fredonia blossomed and produced a crop. Since Erie has no pollen, any fruits set must have been the result of the crossing with the other three varieties. Taking advantage of this circumstance, seeds of Erie were saved in hope that it might be possible to get a variety as early as Erie but with perfect flowers. Twelve hundred seedlings were started in the spring of 1951 and were set at Greenland, New Hampshire, where some began bearing in 1953. All plants with imperfect flowers were removed. This eliminated approximately half of them. Of the remainder, some vines were removed in 1954 because they produced no pollen. The remaining vines were allowed to ripen fruits. Seven of the best selections having perfect flowers were propagated by hardwood cuttings, and plants of each selection were set in the vineyard at Durham along with some standard varieties. In 1956 the grapes were judged for use as fresh fruit and also some grape juice was made from the fruits of each selection. In 1957 No. 26 and No. 37 were the best selections. More time will be required to determine whether either will be named. The outstanding value of these selections lies in their early maturity.



New Hampshire No. 26 grape, a seedling of Erie. It is perfect-flowered and ripens before such varieties as Fredonia and Van Buren.

Pear Breeding

A high-quality productive pear that might follow Clapp's Favorite in ripening season is particularly desired. Crosses were made between Clapp's Favorite and Conference. Pollen was obtained from two trees labeled Conference, but later one was proved to be Buerre Baltet when specimen fruits had been mailed to the New York Agricultural Experiment Station, Geneva, New York, for identification. Several attractive selections have been made from this cross. One designated NH #2 has large, lightly-russeted, spindle-shaped, high-quality fruits ripening soon after Clapp's Favorite. However, it is difficult to tell just when to harvest fruits of NH #2 to avoid breakdown of the flesh near the core. The tree of NH #2 pear is a natural semi-dwarf with wide angle crotches to the branches and might make an excellent filler tree for orchards. The original tree has borne regularly each year including 1956 when some fruits suffered damage from late spring frosts. Trees of NH #2 have been propagated and distributed for testing.

Another seedling has been given the number, NH #4. Though the tree is exceptionally tall and upright, it has produced smooth, attractive, large,

green fruits that store well until mid winter. NH #4 has been late in coming into bearing, but the fruits have sufficient merit so that some nursery trees have been propagated and are being distributed for further testing. Pear blight has not been a problem at Durham, New Hampshire, and there is no reason to assume that these selections have any resistance to this disease. Besides the above cross, over a hundred seedlings having as parents Bartlett, Bosc, Clapp's Favorite, Gorham and Lawrence in various combinations fruited in 1957. One selection has been held for further testing.

Half-High Blueberries

Both the northern highbush blueberry, *Vaccinium corymbosum* L. and the lowbush species, *V. lamarckii* Camp (*V. pennsylvanicum* Lam.), are native in southern New Hampshire. In severe winters, parts of the bushes above the snow line may be killed, though the lowbush frequently escapes injury because of snow covering the plants. Both of these two wild species are tetraploids (2n=48) and natural crosses occur. Many "halfhigh" bushes found in open neglected fields and pastures are presumably the result of such hybridization. These hybrids have darker berries than the parental species which have light blue fruits. Some wild bushes of intermediate stature are probably segregates from the "halfhighs" or from backcrossed generations. Plants derived from the two species interbreed freely.

This fact has encouraged breeding work started at the New Hampshire Station in 1941 when controlled crosses were made between superior named varieties of the highbush and selected plants of lowbush blueberries.* First and second generations have been grown and fruited since that time. F. V. Coville of the United States Department of Agriculture in 1911 made use of a selected wild lowbush from New Hampshire called Russell in crosses with highbush and three cultivated varieties, namely, Rancocas, June, and Weymouth, have resulted. All three have more of the highbush characteristics than are sought in the present breeding work with these two species. Desired particularly is a round-topped bush two feet tall that might be covered by snow naturally or which could be winter-mulched with straw cover and that would have large light blue berries for hand harvesting. Even though lacking full winter hardiness, such a variety might be grown by home gardeners well beyond the present northernmost limits of successful culture of the highbush varieties.

The desired stature for bushes is found in the F_1 of highbush x lowbush, but all F_1 plants of Pemberton x lowbush and Atlantic x lowbush had dark colored fruits of small to medium size. None of seven F_1 plants when 11 years old had exceeded 23 inches in height. Among 954 F_2-bushes that were recorded when 4 years old, the height varied from 5 to 43 inches. Many of these bushes approximated 2 feet in height, but none had the desired combination of large size, light color, high flavor, good scar, and other favorable horticultural fruit characteristics that are being sought. Only 8 plants had real light blue berries, most were dark in color. One plant had reddish ripe berries and 28 had shiny black fruits. In addition, four plants had berries having black skin color with a very heavy persistent bloom and have been

* Selections made by W. W. Smith in wild blueberry fields near Gilford, New Hampshire.

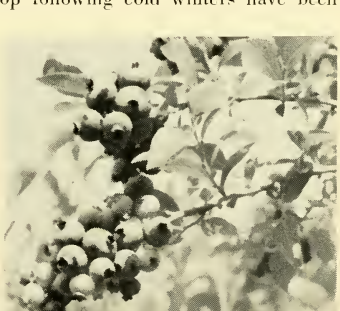
called steel grey color. A number of F_2-bushes have been saved for possible further breeding work, including several that produce stolons readily like the lowbush.

Another highbush species, *Vaccinium constablei* A. Gray, which is a native of the mountains of Western North Carolina, has firm light blue berries of fine flavor borne on bushes that are stoloniferous. This species, which has been winter hardy at Durham, New Hampshire, is hexaploid (2n=72), but crossed readily with the first-generation-hybrids of Pemberton x lowbush. In 1956, some plants from this cross fruited for the first time. The complex-hybrids all bore rather small berries of good light blue color, many with fine flavor, and all were firm as contrasted with the berries of northern highbush x lowbush, many of which tend to be rather soft. Some of the complex-hybrids showed strong formation of stolons.

Backcrosses of the first-generation-hybrids (Pemberton x G-5 lowbush) with cultivated highbush, Earliblue and Bluecrop varieties, were made and of several hundred seedlings being grown, a few fruited in 1956. A sufficient number have fruited to ascertain that relatively more bushes bearing blue fruits are occurring than were found in the F_2 of Pemberton x lowbush. Bushes in the backcross vary markedly in height, but it is too early to make selections for this characteristic.

Hardy Highbush Blueberries

The native highbush blueberry is at its northern limit in New Hampshire. Hence, selections made in this area might have superior hardiness to those from farther south. Two wild blueberries which have fruited when other bushes nearby them have failed to crop following cold winters have been used in crosses with the cultivated highbush. One such wild plant is called Sebatis after the locality in Loudon, New Hampshire, where it was found; another, East Clarendon No. 1 (P. I. 185436), came from East Clarendon, Vermont. Sebatis may have lowbush in its ancestry and is thought of as being perhaps only three quarters highbush. Crosses were made in 1949 with U.S.D.A. No. DN76 (since named Coville), and about 800 seedlings of Sebatis x Coville were placed in a private commercial planting at Rochester, New Hampshire, the following year. Sufficiently cold winters have prevailed since so that it has been learned that both Coville and Sebatis can withstand low temperatures of —20 to —25°F. Their progeny are markedly variable in plant types and other characteristics. Seedlings were removed as soon as they showed serious



A highbush blueberry selection made from several thousand seedlings which have fruited. Several selections are being propagated for wider testing. In addition to size and quality, they have hardiness enough to stand —25° F. without injury.

weaknesses, such as lack of winter hardiness, susceptibility to the fungus diseases powdery mildew, *Microsphaera alni* D. C. ex. Wint., and witches' broom, *Calyptospora columnaris* Kuhn., both of which have given trouble in this progeny, small fruit, soft berries or any serious limitation to continued use of the plant for commercial fruit harvesting. In November, 1956, 248 seedlings remained of the original planting. These will be observed in the future to learn more about their hardiness as some have firm berries of exceptionally fine flavors. It was noted in 1957 that one bush of Coville in the planting at Rochester showed symptoms of witches' broom. Thus, it has now become evident that the cultivated parent used in the cross is susceptible to this disease.

Sebatis was also crossed with Berkeley, Bluecrop, and Earliblue, and U.S.D.A. No. BM22. About 129 seedlings of these crosses have fruited. Seedlings of Sebatis x Berkeley are not promising, due to small size of the berries, but seedlings having berries of good color, flavor, and firmness have been found among Sebatis x Bluecrop seedlings. Earliblue x Sebatis is an outstanding good cross and one desirable selection has been made from a progeny of only 25 plants.

East Clarendon No. 1 wild blueberry was also crossed with Earliblue. The seedlings had a distinctive foliage, being rather pubescent and showing reddish immature leaves similar to the wild parent. Many seedlings bore rather dark colored berries of medium size but rather soft and of insipid flavor. Only one blue-fruited seedling has been selected.

Early Highbush Blueberries

The cultivated varieties of blueberry can be grown successfully in southern New Hampshire. Early-ripening kinds are desired, even earlier than Earliblue. Crosses were made between Earliblue and Bluecrop. This proved an outstandingly good cross with many of the progeny having large fine quality blue fruits. The plants varied in maturity. One selection, NH #4, begins to ripen earlier than Earliblue and seemingly has good horticultural possibilities. Softwood cuttings have rooted readily from this early-ripening selection and it, as well as several other selections from the cross that mature a bit later in the season, will be tested further. About 600 seedlings of Earliblue x U.S.D.A. No. 11-104 are growing in the field. Excellent flavor predominates in this cross, but berries from many seedlings have a soft texture and rather large moist picking scars. Several fine selections have been made from this cross, despite the fact that 180 bushes have been removed because of a severe leaf spot trouble to which some seedlings of this progeny seem susceptible.

Other crosses are Earliblue x Jersey and Earliblue x Baker #1, a selected cultivated highbush from Arrowsic, Maine. While some bushes from these crosses fruited in 1957, they could not be evaluated due to the ravages of wild birds that were exceptionally bad during the dry summer. In all, over 6,000 seedlings are being evaluated. New hardy sorts well adapted to New Hampshire may come from this group.

Peach Bud Sports

At the same time in 1944 that crosses were made between Oriole and P.I. No. 104315 peach from North Caucasus, pollen of the latter kind was applied to emasculated flowers of the Eclipse variety. In 1949, one first-generation tree that had resulted from Eclipse x North Caucasus bore several yellow peaches among the white-fleshed fruits typical of this seedling. Close watch was kept on the tree in 1950 and the small branch that bore yellow peaches was identified and labeled. When cut, the yellow peaches were found to have yellow flesh on the outside and white flesh near the pit with distribution of the two colors being irregular. Following careful pruning to encourage growth of the branch, in 1951 it bore 83 peaches. When cut, 23 fruits showed part white and part yellow flesh. Sixty had yellow flesh except for a white streak extending from the skin to the pit at the suture line. No fruits had completely yellow color. In 1953, 100 peaches from the sporting branch were examined. Eleven had a combination of yellow and white flesh distributed in an irregular pattern; the rest were yellow except for the white suture. A single tree propagated from the sporting branch had all fruits of the latter type. Since this yellow-white peach flesh chimera had mainly academic interest* and the fruits lacked commercial size, it has not been propagated further.

Two separate bud sports were found also on a seedling tree of Oriole x North Caucasus parentage. These sports were both nectarines and they had white flesh color similar to the peaches borne by the first-generation tree. One nectarine sport occurred as a small branch bearing three fruits on one side of the peach tree; the other showed up as a single-fruited spur on a large branch on the opposite side of the same tree. Though the flavor and quality of the nectarines was good, they lacked sufficient size for propagation as commercial varieties. The several sports noted among this small progeny of first-generation trees does indicate that bud sports happen commonly and that careful and close observation of peach seedlings in a breeding program might even yield some bud sports worthy of commercial propagation. Most known commercially propagated bud sports of the peach have been selected from orchards planted to named varieties.

Other Peach Breeding

As mentioned in New Hampshire Station Bulletin No. 383, a shortcut has been found in breeding peaches so that only those seedlings destined to have yellow fruits need be saved from a progeny known to be segregating for white-fleshed and yellow fruits. This discovery made in the spring of 1949 has greatly reduced the number of seedlings it is necessary to fruit in the field. Before the seedlings emerge from the soil they will be white or yellowish color corresponding to the flesh color of the fruit which they will produce when the trees have been grown to fruiting age. Since 1949, in the backcrosses that have been made between the first generation hybrids of

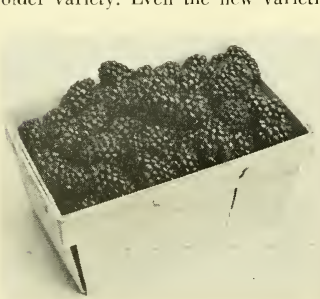
* A. F. Yeager and E. M. Meader, "A Flesh-Color Chimera in the Peach", Journal of Heredity, Washington, D. C. Vol. XLVII:77-78, 1956.

the North Caucasian peach and Oriole and certain commercial varieties, including Meredith and Jerseyland, stones of the peaches have been cracked in the spring following stratification and the seeds germinated in sand in the greenhouse. Just as the seeds are germinating and beginning to come up through the sand, the young seedlings are classified as to color. About one-half are white and are discarded. Only those showing yellow color have been planted in the field. At least 95 percent accuracy has been possible by this method of early elimination of undesired seedlings. The accuracy is better for predicting flesh color of the fruits than that of trying to use the color of the midribs of the leaves in the early fall of the first year the seedling trees have grown in the field.

Progress is being made also through the use of genetically hardy peach parents which include a white-fleshed seedling from Minnesota which has been combined with yellow-flesh selections made in New Hampshire. Crosses have been made also between a white-fleshed nectarine, Nectarcrest, and hardy yellow kinds. The first-generation white fruits have had unusually fine edible quality, but little has been learned yet regarding their relative hardiness.

Blackberries

The blackberry is not a dependable cultivated crop in New Hampshire, although wild blackberries are abundant. The hardiest of the cultivated varieties is Snyder, but its fruits have poor quality and the berries are rather small. A probable seedling of Snyder, known in the state as Maple Grove, resembles Snyder closely and is somewhat better in quality than the older variety. Even the new varieties from the Geneva, New York, Experiment Station have killed back too badly most winters to give a satisfactory crop. A cross made between L6, one of the New York varieties, and Snyder resulted in many seedlings, one of which is being distributed in a limited way as New Hampshire #1 Blackberry. It is productive of large berries and may be nearly as hardy as Snyder. While this is not the best possible variety, it is an improvement over present ones. Crosses have also been made between Geneva No. 32, the best of the New York varieties for quality, and a selected nearly thornless wild blackberry from nearby New Hampshire woods. None of a considerable number of seedlings have seemed promising up to the present. Presumably they are triploids. They are rather hardy, but are partially sterile. It is proposed to grow a second generation from the best of these.



New Hampshire No. 1 blackberry. This selection has larger and higher quality fruit than Snyder, the present standard of hardiness.

Other Blackberry Breeding

Another complex blackberry hybrid which seems to offer some possibilities is one obtained by pollinating New York 32 blackberry with pollen from a triploid hybrid made by crossing Hailsham tetraploid raspberry with Korean Tree Berry, *Rubus morifolius*. Some of the plants from this complex hybrid involving three species are hardy with fruits which look like blackberries.

Early Harvest Blackberry Crosses

Early Harvest, a diploid cultivated blackberry, when crossed with selected nearly thornless wild blackberries presumed to be *Rubus canadensis*, has given a fairly hardy self-fertile F_2 progeny. Among this progeny may be a worthwhile early variety. Succeeding generations will also be grown. Early Harvest blackberry has been crossed also with both the red raspberry and the black raspberry, *Rubus occidentalis*. Both of these interspecific F_1 generations were almost completely male sterile. Some seeds were produced by open pollination in the field, and a small F_2 generation of Early Harvest x black raspberry has been grown. Some of the plants in this second generation appear to be promising breeding material. The plants are partially self-fertile. Early Harvest blackberry has been pollinated also in the greenhouse with pollen from a *Rubus ideaus* x *Rubus arcticus* plant No. 49-201-1 which came from Finland by way of Canada. The F_1 generation from this cross involving three species is a variable progeny ranging from plants only a few inches high to some four feet high. All these seedlings are male sterile or nearly so, and they give no self-pollinated fruits. Some viable open-pollinated seed has been procured from them. In the greenhouse, seed has been produced by pollinating the hybrid plants involving the three species with pollen from red raspberry and New Hampshire #1 blackberry, *Rubus canadensis*, and a partially fertile hybrid of *Rubus odoratus* x Durham raspberry. The seeds have been stratified. Such wide interspecific crosses are exploratory, yet may eventually give worthwhile new varieties. A cross was also secured between Early Harvest and *R. pubescens*. Although the F_1 was male sterile, an open-pollinated F_2 has been grown and seeds have been saved for F_3.

Blackberry x Rubus Odoratus

A cross between *Rubus odoratus* 2n flowering raspberry and Snyder blackberry 4n gave a sterile 3n hybrid. When the chromosome number in these plants was doubled by the use of colchicine, a fertile plant was produced. It was not horticulturally valuable. Seedlings from this have resulted in fertile plants resembling the F_1 cross. One such selection is 4n, another is 6n.* The fruit is purple; the plants are nearly thornless. Since the fruit adheres tightly to the plant, their only value is as breeding material.

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* Chromosome counts were made by Richard Schreiber, a graduate student in Horticulture, University of New Hampshire.

On the left, a cross between Snyder blackberry and *Rubus odoratus* which is sterile. On the right, the plant has been made fertile by doubling the chromosomes with colchicine.

New Hampshire Red Raspberry

As reported in New Hampshire Station Bulletin No. 383. Taylor red raspberry was pollinated within a screened greenhouse in the spring of 1943 with pollen of *Rubus chamaemorus*, the baked apple berry. Open-pollinated seeds were saved in the field from the small red-fruited first generation plants that grew about two feet tall. The second generation seedlings were extremely variable in height. One strong-growing, somewhat branched plant was selected and called NH #101 (also carried by some cooperators as NH #104). Hardy and productive, this selection which was named New Hampshire and introduced commercially in 1955, has large conic red berries with a long slender torus or receptacle. This makes for rapid harvesting of the easily-picked berries that are outstandingly firm. The bright red berries have good flavor fresh and also canned or frozen. The fruits ripen towards midseason, but the picking period extends over a period of several weeks. In 1956, the first picking came on July 23 and the last harvest was made August 24. A total yield of three and

A collection of plants showing the variability in the second generation from crosses between red raspberry and *Rubus chamaemorus*, the latter being an herbaceous octoploid species.

one-half pints per foot of row was recorded for a 50-foot row grown in clean cultivation. New Hampshire responds to heavy fertilization and produces an ample number of sucker plants, though it tends to sucker less than some varieties. Many of the suckers tend to arise three and four feet from the parent plant and these may be readily controlled by cultivation or this fact must be taken into account when a nurseryman wishes to propagate large numbers of plants. While New Hampshire cannot be rated resistant to common raspberry diseases, with good cultural practices it is proving a fine commercial kind for New Hampshire and is liked by the home owner.

Success Purple Raspberry

Another selection from the second generation mentioned above under the New Hampshire raspberry was designated NH #100, a much-branched, low-growing three-foot-tall, red raspberry. While this selection failed to become popular under further testing, it served as a pollen parent in breeding work. Morrison black raspberry was pollinated by NH #100. A progeny of purple raspberries resulted. Six of the best seedling selections were propagated for row tests. After testing both on the Station grounds and elsewhere, NH #P-4 was chosen for naming. The name Success was given to this new variety introduced in 1956. The medium to large size purple berries are sweet, being less tart to the taste as fresh fruit than are most kinds of the purple raspberry. The flavor is excellent as fresh fruit and excels for both frozen and canned products. Flavor of the canned fruits has been compared to the Loganberry. Many who have tried the Success raspberry prefer its flavor to all other kinds. The flavor resembles the black raspberry somewhat, though it is distinctive in itself.

The plants are highly productive. Eleven plants in a private garden lightly pruned to trellises yielded 120 quarts of fruit in 1956. The strong-growing arched canes exceed six feet in height and some canes may measure 10 to 12 feet to the tip when allowed to grow freely. The tips of the canes may root late in the fall. Also the plants produce some sucker shoots after the plants have become well established. Both of these means may serve for propagation. When large plants have been dug up for transplanting, many young plants are regenerated from roots remaining in the soil. Resort has been made to softwood cuttings of the primocanes to hasten the increase of this variety. Such cuttings taken in July and placed in either a mist-nozzle or Wardian case propagation frame give rooted plants, the strongest of which may be field planted; others may be wintered successfully in a cold frame where they may be mulched with sawdust to be planted in the open field the following spring.

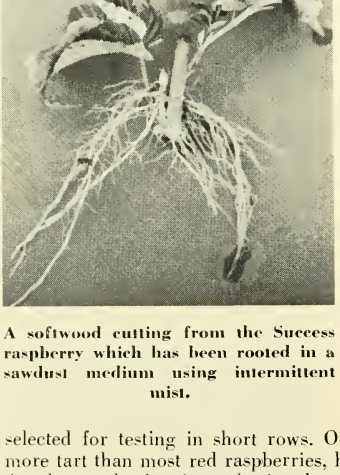
Success raspberry, a purple variety of unusual quality and high productivity.

Success raspberry has been resistant to spur blight, a serious disease of the red raspberries. It is not immune to anthracnose which frequently bothers black raspberries. Plants of

Success that were given good culture withstood —25° F. with only slight injury to the top during the winter of 1956-57 in New Hampshire. Because of its hardiness, productiveness, fine flavor, and easy culture, Success raspberry should appeal strongly to those home owners who choose to grow raspberries. On markets that are accustomed to purple raspberries, Success may also prove to be a fine commercial market variety.

Rubus Pungens Crosses

A special strain of *Rubus pungens oldhami* was introduced by Mr. E. M. Meader in 1947 from Korea. This low-arching and decumbent species is partially hardy at Durham. It has pink flowers, borne singly, followed by fruits that are large, orange in color, and very acid. Its valuable outstanding characteristic is extreme earliness. Here in southern New Hampshire it ripens around June 20. When *Rubus pungens oldhami* was crossed with black raspberry it made partially sterile F_1 plants which bore fruits with garnet-colored druplets. When the second generation was raised, most of the seedlings had little value. One or two looked good enough so that seeds from them have been grown for an open-pollinated third generation.



A softwood cutting from the Success raspberry which has been rooted in a sawdust medium using intermittent mist.

When pollen of *Rubus pungens oldhami* was used on Taylor red raspberry as a female parent, F_1 plants resulted that were productive and rather hardy; yet, not valuable enough to be a variety in themselves. An F_2 population of several hundred seedlings was raised from these hybrid plants. As might be expected there was great variability. The plants varied from tip-layering spreading low plants to upright plants resembling red raspberry. Only a few seedlings had pink flower color similar to *Rubus pungens oldhami*. Most seedlings had red fruits, although there were some plants with orange and some with yellow fruits. Among them were several that had attractive large fruits that ripened the latter part of June. These were selected for testing in short rows. One selection, with red fruits somewhat more tart than most red raspberries, has been found to make good preserves. Another early-ripening selection has large yellow berries and fruited from June to frost in 1957. Whether any of these will become a variety remains to be seen. Several have potentialities for the introduction of genes for extra-early ripening into cultivated raspberries. Seeds from several of the best selections have been saved for another generation. Also crosses have been made with certain selected everbearing raspberries.

Summer Bearing Raspberries

With the introduction of the Durham variety, described in Station Bulletin No. 383, it became possible to produce a profitable fall crop of raspberries in northern states. However, the northern part of New Hampshire has such a short growing season that little fall crop ripened there. The next forward step in raspberry breeding can be varieties which will ripen on the new canes in mid-summer at the same time that ordinary raspberries are ripening from over-wintered canes. This seems to be a definite possibility. Plants showing such early fruiting on primocanes have been discovered in several different progenies. Descendents from *Rubus Odoratus* x Durham have produced a summer crop ripening in July from canes which came from the ground the same season. These seedlings have not been good enough to name as a variety. A red raspberry seedling has been discovered also which sends up from the ground canes which ripen berries in mid-summer. For breeding purposes only, it has been called Summer Red. There would seem to be possibilities in getting varieties which would ripen fruits on new wood from such species as *Rubus chamaemorus* and *Rubus arcticus*. Both of these species which we have already used in breeding work send up from the ground shoots that blossom and fruit the same season. Selected plants that bear early in the summer on primocanes are being crossed with other raspberries with the objective of procuring raspberry varieties which need not have canes over-winter above ground for satisfactory fruit crops. Susceptibility to cane diseases might also be avoided as the diseases might not carry over to the new sprouts.

A sprout of a Summer-bearing raspberry.

Other Raspberry Breeding

As mentioned in Station Bulletin No. 383, reciprocal crosses were made between Durham raspberry and *Rubus odoratus*. The F_1 hybrids had pink flowers, a low stature, and proved to be less hardy than either parent. They produced almost no suckers, although both parents sucker freely. It has been possible to propagate the hybrids successfully by softwood cuttings. Of 25 F_1 hybrid plants, all proved sterile except one that did mature a few scattered druplets. The somewhat fertile plant has been used in crosses with other selected plants of *Rubus* and seems to work well as either a male or a female parent. Some promising selections have come from crosses with New Hampshire red raspberry.

A cross between Taylor raspberry and Korean Tree Berry, *Rubus morifolius*, where both parents are diploids, give nearly sterile F_1 hybrids. When carried into a second generation, no valuable selections resulted. However, Hailsham red raspberry, a tetraploid variety, was crossed with *Rubus morifolius* and a resulting 3n plant proved fertile and nearly good enough to introduce as a variety. When an open-pollinated F_2 generation was raised from this triploid hybrid, all 16 plants on which chromosome counts were made were diploid.* The plants were mostly sterile, extremely variable, and showed some characteristitcs of both parental species. Backcrosses of the triploid hybrid to New Hampshire raspberry gave a good progeny, but the seedlings showed little or no evidence of *R. morifolius* plant characteristics.

Everbearing Black Raspberries

Following the crossing of Morrison black raspberry and Durham red raspberry, a progeny of purple raspberries resulted. One selected fall-bearing, purple-fruited seedling was in turn backcrossed to black raspberry by Putnam Payne, a graduate student in Horticulture.

As a result, a plant ripening berries closely resembling a black raspberry and that mature rather early in the fall was obtained. In itself, this black raspberry has been difficult to propagate by the customary tip-layering method, but has been increased by means of softwood cuttings. A generation of self-pollinated seedlings from this fall-fruiting black raspberry gave both black and purple raspberries that were fall-bearing. As noted, everbearing black raspberries seem difficult to propagate aside from the use of softwood cuttings. The fruiting of the terminals makes tip-layering impossible.

Blaze Strawberry

From crosses made by Dr. L. P. Latimer between a selection from Simcoe x Pathfinder and a selection of Tupper x Fairfax, there was selected in 1948 an attractive seedling that received the number, NH #288. This perfect-flowered selection had medium to large bright red, somewhat rounded berries that ripen in midseason. The berries, though having a light-colored interior, ripen to a brilliant red outside, hence its name. The berries are rather soft and must be handled carefully in harvesting. Since it was named as a variety in 1953, Blaze has continued to be highly productive with yields of 15,000 quarts per acre having been reported in trials at the Massachusetts Agricultural Experiment Station. For nearby local markets and home use, Blaze has proved popular. Due to their light interior color, the fruits are not satisfactory as a commercial frozen berry, though the flavor is rated pleasant after removal from the freezer. The strong plants have large crowns and make runners freely. Leaf spot has seldom been a serious problem with this variety.

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* D. L. Craig, a graduate student, University of New Hampshire.

Strafford Strawberry

A selection given the number, NH #266, was made by L. P. Latimer from a progeny of seedlings that came from crossing a selection of Simcoe x Catskill with a selection of Tupper x Fairfax. NH #266 was named Strafford and introduced in 1954. The deep-red, large berries hold their size well throughout the harvest period that comes late in the season. The ripening of fruits begins 10 to 14 days after Howard 17. The perfect-flowered plants make runners freely. Strafford should be considered as a variety where a late-ripening sort is particularly desired.

Jamberee Strawberry

A University of New Hampshire seedling strawberry has been named Jamberee by J. Lincoln Pearson, nurseryman of Rumney, New Hampshire. This variety was originally known as N. H. No. 152. Its parents were a pistillate, superior seedling of the native field strawberry (*Fragaria virginiana*) and Catskill.

Jamberee berries are intermediate in size between the wild and cultivated sorts and possess the much desired "wild" flavor of the *F. virginiana*. The plants are vigorous and produce large clusters of berries which ripen early in the season. The fruit is ideal for jams and jellies, and for freezing.

Merrimack Strawberry

In the spring of 1949, within the greenhouse, a late-ripening pistillate strawberry selection, known as No. 179 from a cross of Tupper x Fairfax, was pollinated with pollen from the late-ripening, high-quality variety, Fairpeake. Several perfect-flowered late-ripening, selections with attractive fruits were made in 1951. Of these, Merrimack has continued to be grown because of its high-quality fruits that ripen late in the season. The glossy, bright-red berries with a tough skin have some of the sweet flavor of Fairfax, which is lacking in commonly grown late-ripening types. The plants of Merrimack make large vigorous crowns and when grown in the matted-row system of culture, the runners must be widely spaced to give the good yields of which the selection is capable. Low yields may be expected from crowded plants. Such a late-ripening kind as Merrimack must be grown on a soil that holds moisture well or be given irrigation to insure a good crop of late berries. Considering the price advances for berries late in the season, Merrimack has been considered suitable for the commercial market. Plants indexed* and found to be free of common serious virus diseases are being increased by nurserymen.

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* NH No. F-13 plants were indexed by runner grafting to the East Malling clone of *Fragaria vesca* by Robert Becker, graduate student, Plant Pathology Department, University of New Hampshire.

Almonds

The almond, which is closely related to the peach, has only similar winter hardiness to that rather tender fruit. The Hann variety, a hard-shell almond, bears at Durham, New Hampshire, whenever there is a season favorable for a peach crop. This has stimulated further variety testing of any almonds reputed to be above average in hardiness. Similar to the peaches, if the almond fruit buds survive the winter, there is seldom a crop lost due to spring frosts.

The almond flowers, highly ornamental when in blossom, are insect-pollinated similar to most fruit trees. As the Hann almond trees stand in a block of the hardier varieties and selections of the peach, it was decided to grow some open-pollinated seedlings from the almonds, since it is known that crosses with the peach are successful. Trees resulting from this venture are extremely variable and their fruiting will be awaited with much interest. A small tree having ornamental value in leaf and when in flower, and that would produce a usable nut, would be welcomed by home owners.

In 1942, *Amygdalus nana*, Siberian almond, a 3-foot bush, was crossed with almond using pollen mailed from California. A considerable number of seedlings resulted, but all but one proved to be weak and perished within two years. One has survived and is now 6 feet high. It is more hardy in bud than peach, but has never produced fruit because the pistils are abortive. It does, however, produce pollen. Eventually this approach may make possible the introduction of greater hardiness into almonds.

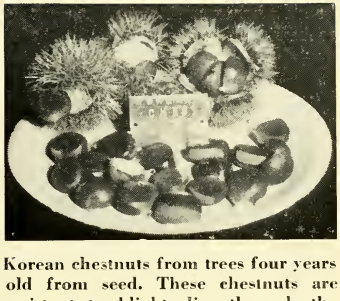
Chestnuts from Korea

Ever since the destruction of the American chestnut, *Castanea dentata*, by chestnut blight in the early years of this century, there has been an interest in chestnuts to replace the native species. The Chinese chestnut, *C. mollissima*, which has been introduced to this country from the Orient, has been rather highly resistant to disease. When tried in New Hampshire, most of the Chinese chestnuts, both seedlings and named varieties such as Nanking, Abundance, Zimmerman, and others, have not been well adapted, though they have suffered little from the chestnut blight. Although the trees survive winter temperatures of —20° F., there is sufficient heat only in an unusually warm summer with a longer than average frost-free period to enable the nuts to fill properly and mature before an injurious freeze occurs in the fall. Such results may be related in part to the fact that the original collection of nuts in China was made in the southern and milder part of that country.

In 1947, E. M. Meader, at that time Horticulturist for the United States Army Military Government in Korea, collected chestnuts from the city markets in Seoul, Korea, and forwarded the nuts to the Horticultural Department, Durham, New Hampshire. From these nuts, trees were grown that produced their first crop when four years old. The seedlings, with one or two exceptions, seemed botanically to be *Castanea crenata*, commonly called Japanese chestnut. One or two of the trees somewhat resembled the Chinese chestnut, though the probability of their being of hybrid origin

can hardly be ruled out. Most all chestnut trees tend to be self-unfruitful and require cross pollination.

The chestnuts from Korea, while not immune to blight, have been highly tolerant of the disease under conditions of a severe test. American chestnuts that have blighted repeatedly have been allowed to grow along with and in among the seedlings from the Orient. A small twig on a branch of the chestnuts from Korea may take the blight, but only a small lesion or canker is formed near the point of infection and seldom is the branch greatly injured as the lesion tends to heal over in subsequent years. When left unpruned under the conditions of this severe testing, only a few small branches have died from blight. Ten-year-old American chestnuts of the same age have been killed to the ground level repeatedly. They have sprouted several times during this interval of time to serve continually as a source of blight infection in the planting.



Korean chestnuts from trees four years old from seed. These chestnuts are resistant to blight, live through the winter without injury, and ripen their crop in southern New Hampshire most years.

The trees from Korea have matured well-filled nuts of good sweet edible quality in the average summer season at Durham. This particular planting happens to be in a low place subject to late spring frosts, and frost injury to the flowers when in blossom has caused a crop failure two different seasons. Thus a relatively frost-free site should be chosen for the Oriental chestnuts, even as for fruit tree crops commonly grown commercially in orchards. The chestnuts from Korea have a tree of a spreading growth habit and they thrive when either clean cultivated or maintained under a mulch system of management similar to the apple.

The chestnuts from Korea seem equal in winter hardiness to the Chinese chestnut, but they are not fully equal to the American chestnut in this regard. The nuts from the Korean chestnuts surpass those of the American in size though neither equals the European chestnut in this respect. The nuts harvested at Durham from the original seedling trees from Korea have been used primarily to grow seedlings for distribution to persons interested in testing further the possibilities of this Oriental chestnut.

NH No. 3 Chestnut

A chestnut tree planted many years ago on the Gowen Brothers Farm, Stratham, New Hampshire, has continued to live and bear occasional crops through the years, although blight has damaged the tree considerably. Ten seedlings were planted at Durham from nuts harvested from the tree growing in Stratham. Only one of the seedlings lived to fruiting age. It has unusually large, good-quality nuts and has been designated NH #3 chestnut for limited propagation. Similar to the chestnuts from Korea, NH #3 chestnut resists blight, but is not immune. In fact, even though the Stratham tree had been called a "Turkish" chestnut, it so closely resembles the trees from Korea, that it seems that it must be an early importation of the Oriental

chestnuts. How readily NH #3 chestnut can be propagated has not been determined, but it has been top-grafted successfully into another chestnut tree in West Virginia.

American Chestnut Seedlings

Chestnut blight ravaged the native chestnut forty to fifty years ago. Since that time, American chestnut seedlings have volunteered in the woods of New Hampshire and along stone fences. Most of these seedlings have been killed back by blight but persist due to sprouts that form near the ground. Occasionally, a seedling becomes large enough to bear some chestnuts. Due to the authors' continued interest in the American chestnut, some of these fruiting trees have been called to our attention.

In 1947, a large tree more than a foot in diameter growing on the John L. Hay estate, Newbury, New Hampshire, was visited and found to be bearing nuts and without visible blight at the time. Nearby were many chestnut trees that had blighted to the ground repeatedly. From nuts sent to Durham, 20 seedlings have been grown. Most of them have blighted, some repeatedly, but a single tree has reached fruiting age and has produced several nuts. The tree is now 15 feet tall and has a diameter breast high of 4 inches. Sister seedlings 12 feet either side of this particular seedling have blighted badly. Now in 1957, after a period of ten years, this seemingly-resistant seedling has taken the disease. With further reference to the parent tree in Newbury, it has been learned that in 1948 blight injured the tree. Thus it takes many years to test adequately any chestnut seedlings.

Nuts of American chestnut have been received for planting also from H. Clifton Dyke, Grasmere, New Hampshire, and Carl Valyou, Mason, New Hampshire. Any seedlings that continue to remain free of blight will be watched with much interest.

Hybrid Chestnuts

While the chestnut does produce both male and female flowers, a single tree is self-unfruitful and it matures no viable nuts unless cross-pollinated by another tree. Some years ago, some American chestnuts that had grown in Pennsylvania were planted at Durham. All of the trees succumbed to the blight except one which in 1952 was a rather upright, yet spreading tree about 15 feet tall. The tree had shown some winter injury during the years. When it blossomed profusely in 1952, this isolated tree proved pollen-sterile. The leaves indicated that it was a hybrid tree, and it seems that there must have been natural cross-pollination with introduced oriental chestnuts in Pennsylvania to produce the nut from which this hybrid tree grew at Durham.

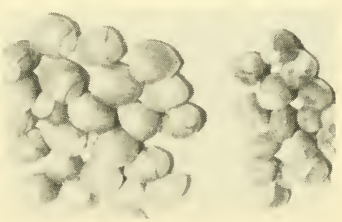
Taking advantage of this fortuitous circumstance, this isolated and pollen-sterile hybrid tree was pollinated with pollen from selected trees of the chestnuts from Korea. Thus a backcross between the American and Oriental chestnuts was readily accomplished. In the meantime, the tree used as female parent has been badly injured by blight and winter injury and can hardly be expected to bear nuts again.

Furthermore, first-generation hybrids of the *Castanea crenata* from Korea and the American chestnuts in Mason, New Hampshire, called to our attention by Carl Valyou, have been crossed. Pollen from the American chestnut in Mason, was mailed to Durham and later applied to an isolated Korean chestnut grown at Rochester, New Hampshire. The tree used as female parent was emascultated although it proved self-unfruitful.

None of the seedlings resulting from these interspecific crosses have fruited yet, but they are making some fine vigorous trees. Perhaps, in time, there may be a blight-resistant forest-type tree result from such endeavors. It has become apparent that varieties of the Oriental chestnuts found successful in areas south of New Hampshire are poorly adapted in this state, and to make progress towards adapted disease-resistant chestnuts, the breeding and selection must be done in this area.

Hazel-Filberts

Several hundred seedlings have been grown from open-pollinated crosses between American hazel and European filbert. There is great variability among them in form, stature, and productivity, as well as size and shape of nuts. Among them are many worthy of propagation. The difficulty with this nut is that no cheap and easy method of propagating has been discovered. Mound-layering works, but this is slow and expensive. Another difficulty lies in the fondness of gray squirrels for the nuts. Unless drastic measures are used, the crop will be removed before it is fully ripe. Blue Jays are another problem. They gather in flocks when the nuts are ripening and swallow them whole. If the birds and animals can be controlled and a better method for propagation discovered, this could be a commercial crop in New Hampshire. The flavor of many of the selected nuts is better than European Filberts. The hazel-filberts stand more winter cold than peaches, some of them resist spring frosts, and many of the seedlings tend to bear annually. Several of the best selections are being mound-layered.



A selected hazel-filbert hybrid, on the left, compared to the Winkler which is the largest of the cultivated American hazels that we have grown.

English Walnuts

There are English walnut trees bearing in a number of places in New England. Extra hardy trees are also reported elsewhere. Seed from some of these have been secured and trees are being grown. None of these have fruited as yet. It seems reasonable to expect good varieties eventually which will be at home in southern New Hampshire.

Heartnut and Butternut Hybrids

The Japanese heartnut, *Juglans sieboldiana*, a winter hardy and a fast-growing tree at Durham, somewhat resembles the native butternut, *J. cinerea*. In the spring of 1951, Radcliffe Pike, graduate student in the Horticulture Department, University of New Hampshire, pollinated a heartnut at the Horticultural Farm with pollen from one of the best native butternuts in the station plantings. In the fall of 1956, 8 or 10 nuts were harvested from a hybrid tree then only 4 years old. Only pistillate flowers were produced by this hybrid tree in the spring of 1956. Some wild butternuts grow about 75 yards from the spot where the hybrid tree stands in a private garden in Rochester, New Hampshire. It is thus assumed that these nuts should give a backcrossed progeny and it has been possible to grow two such seedlings for field planting in 1957. Also in 1957, the F_1 tree again bore only pistillate flowers, so it has been possible to obtain more backcrossed nuts for planting. The hybrid tree, sometimes called a "buartnut", is vigorous and not subject to leaf troubles, though it is attacked by lace-winged insects similar to the parental species. There may be possibilities for improvement of the native butternut through this breeding approach. When 4- or 5-year-old trees can be fruited, progress can be made seemingly as fast as with the peach. Methods for propagation of any new selected nut will have to be worked out. Butternuts are propagated vegetatively with some difficulty.

William E. McGrath

Nesmith Hall

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